

# The Story of **COMETS**



**Binaya Krushna Pattanayak**  
BHARAT GYAN VIGYAN SAMITI



## THE STORY OF COMETS

Presentation :

Binaya Krushna Pattanayak

Illustration :

Braja Kishor Jena

Publisher :

BHARAT GYAN VIGYAN SAMITI

West Block-2, Wing-6

R.K. Puram, Sector-1

New Delhi-110066

Phone : 6107911, 6107318

Publication Period :

August, 1996

Price : Rs.10.00

Cover : A Comet and its train wander among the other  
lights of the night sky. (From Grandville's Un  
Autre Monde, 1844)

This book is published by the

Bharat Gyan Vigyan Samiti as a part of the  
Jan Vachan Andolan sponsored by the National Literacy Mission.

## THE STORY OF COMETS

This Copy is

dedicated to the

late Prof. N.C. Rana,

Ex-Chairman, Confederation of

Indian Amateur Astronomers' Association.

**BINAYA KRUSHNA PATTANAYAK**  
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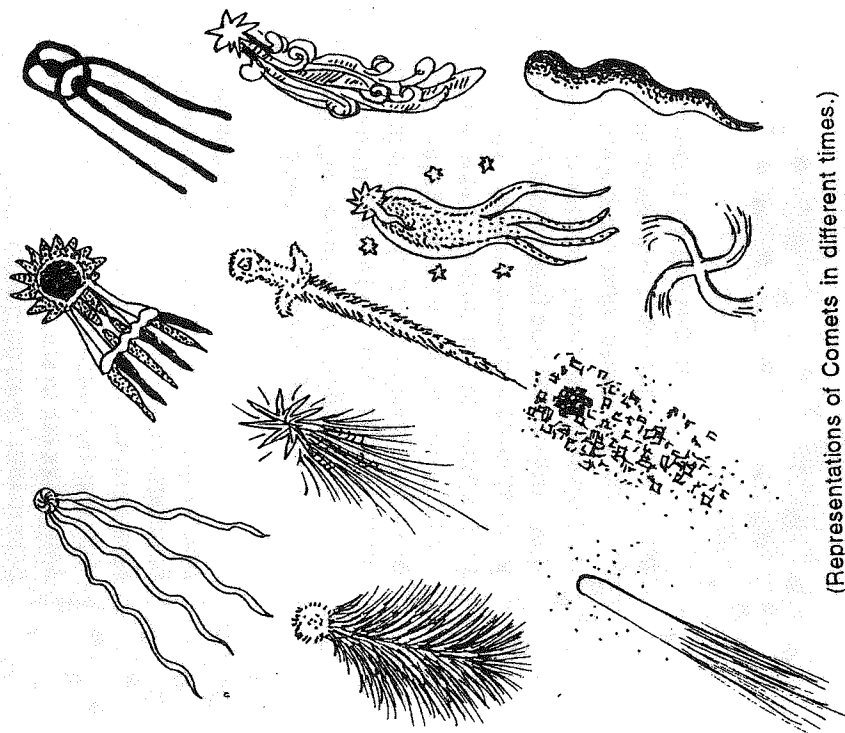
## The Sky overhead

From time immemorial, humans have enjoyed an intimate relationship with the sky. For primitive people, the sky acted both as a clock and calendar. All their activities were organized as per the visibility of the celestial bodies. They slept among the stars. They looked at the sky to tell them what to do. Accordingly, they went to camp, to hunt, to plough land, to move or to remain in caves. They expected heat, rain or cold as per the illuminations in the sky. They were not only dependent on the sky, but they were rather moved by its beauty and diversity. They kept on investigating it through hypotheses, explanations and metaphors.

Gradually, they got acquainted with the everyday celestial bodies through observation and logical calculations. But sometimes they were fascinated by new visitors in the sky. They were meteors, asteroids and comets. Among them the comets were quite eye-catching and surprising. With time, humans have succeeded in deciphering the truth about the comets, but till today the civilization is yet to be convinced by the reality.

## Comets in History

If we look at history of comets, we can have an overall idea. For ancient people, the shape, colour and size of the comets were the same like we see them today. But still, their interpretations were quite different. They looked at them with their own feelings and drew their pictures accordingly. The word "comet" was generated basing on these observations. Greek people gave them this name "Kometes". Kometes means "hairy one". But this hairlike appearance was not common to all sky watchers.



(Representations of Comets in different times.)

## Shapes

The *Tshi* people of Zaire called them as **hair stars**. *Chinese* people described them as **broom stars**. Other cultures narrated them as **tail stars** or **stars with long feathers**. Today also we feel comets as having tails. *Tonga* people meant them as **stars of dust**, which is quite close to the truth. To *Aztecs* these were **smoking stars**. People in *Jerusalem* took them as **sword** hanging over Jerusalem.

The *Greeks* credit the *Egyptians* with the idea that the tail of a spectacular comet resembles a **women's long hair**. In other ancient descriptions, the tail is an **axe**, a **scimitar**, a **sword**, or a **dagger**. Clearly we are dealing with a twisted version of the old saying, "beauty lies in the eyes of the beholder". The famous **swastika** symbol in *India*, *China* and *Germany* also is supposed to have been generated from the shape of specific comets only.

- Around 900 B.C., Homer used the image of a comet to inspire fear in his audience when describing Achilles' helmet :

*Like the red star that from his flaming hair,  
Shakes down disease, pestilence and war.*

The "flaming hair" refers to the great tails of the bright comets.

- In Shakespeare's *Julius Caesar* we find :

*When Beggars die there are no comets seen.  
The heavens themselves blaze forth the death of the princes.*



## Interpretations

Along with these shapes, people linked up peculiar interpretations. In most societies, they were taken as symbols for danger, or evil incidents. Throughout the world, with very few exceptions, comets were described as harbingers of unwanted change, ill-fortune and evil. Perhaps only the **Kung** community in ancient Namibia were optimistic. They interpreted them as a guarantee of good times ahead. Kungs were a hunting community, who were closure to the long term human norm than almost any other culture today.

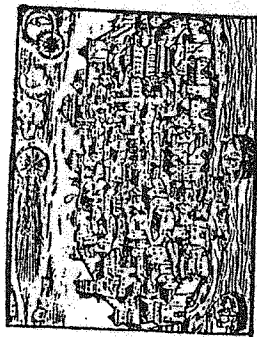
Others were quite pessimistic about comets. In their myths, the tribal people of *Africa* have expressed all sorts of fear and surprise. To Masai people of *East Africa*, a comet meant **famine**; to the *Zulu* of the south Africa it meant **war**; to the *Eghap* of *Nigeria*, **pestilence**; to the *Djaga* of *Zaire*, specifically **small pox**, and to their neighbours, the *Luba*, the **death of a leader**.



( This French Cartoon of 1857 depicts a fear that still exists today - that a comet may hit the Earth and cause widespread destruction.)



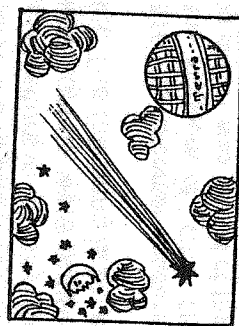
Mexican King and Comet



Halley's Comet over Nuremberg (684)



King Harold and comet of 1066



Allarm to Europe, 1680

## Records say .....

Chinese records have been a gold mine for comet study. They include descriptions and dates of some 600 comets. According to records, the earliest one was of 2315 B.C. The Chinese observed the paths of many "broom stars" among the stellar constellations of their sky maps. Halley's famous periodic comet can be traced back to 240 B.C. in the Chinese writings.

Until the 17th century, Western astrologers were more interested in interpreting the dire forebodings of the comets than in keeping track of their movements on the sky. We owe an enormous debt to these Chinese recordkeepers, because comets carry no name tags. The only way we can identify them is by their position among the stars at a given time.

A Chinese sentence of 15th century B.C. says :

*When Chieh (the ruler) executed his faithful counsellors, a comet appeared in the sky.*

Another Chinese write-up says :

*When King Wu-Wang waged a punitive war against King Chou, a comet appeared with its tail pointing towards the people Yin. The Yinrites were in trouble !*

In most cases, they interlinked the comets with all problems and bad times. It was quite unfortunate for these guest visitors in the sky. But there are also few instances where comets were appreciated and were taken in right spirit. The following is an example of that :

In 516 B.C, a comet appeared in the kingdom of Ch'i. The King of Ch'i was afraid of this. He wanted to send his ministers to pray to heaven. But Yen Tsu dissuaded the king. He said, "It is useless. You are only fooling yourself. Whether heaven will give you a disaster or good fortune is set, it won't change. How can you expect prayers to change anything ? A comet is like a broom : it signals the sweeping away of evil. If you have not done anything evil, why do you need to pray ? If you have done something evil, praying won't avert disaster. The work of the Ministers of prayer won't change fate."

( The Comet drama in 516 B.C. )

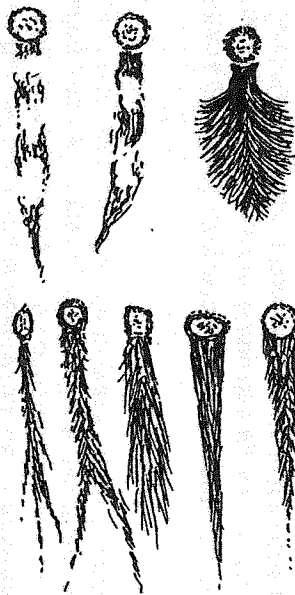
The king was delighted to hear this. He ordered the praying stopped. It took a dramatically different turn !



## Some dumb witness.....

Towards 1970 some excavations at Mawangalui in China revealed some useful evidences. It showed the pioneer work done by China in observing and understanding the comets. The 'Number three tomb' had a compilation of comet datas of around 300 B.C. Twentynine comets were displayed. They were classified as per their appearance. Out of 35 comets, eighteen have been named. As per it :

- ☞ The Four-tailed comets signified *Disease to the world*.
- ☞ Three tailed comets indicated '*Calamity in the state*' ;
- ☞ Two-tailed ones which curved to their right signified '*small war, but good agriculture*' ;



( The Chinese classification of Comets, 1970 )

## Record of the world's change

The "Record of the world's change" mentions about comet the following way :

- ☞ Comets are vile stars. Everytime they appear in the south, something happens to wipe out the old and establish the new. Also, when comets appear, whales die. In Sung, Ch'i and later Chin times, when a comet appeared in the constellation of the Big Dipper, all soldiers died in chaos.

☿ When a comet appears in the North star, the Emperor is replaced. If it appears in the end of the Big Dipper, everywhere there are uprisings and war continues for several years. If it appears in the bowl of the Dipper, a Prince controls the Emperor. Gold and gems become worthless. Another explanation : Scoundrels harm nobles. Some leaders appear, causing disturbances. Ministers conspire to rebel against the Emperor...

☿ When a comet travels north but points south, the country has a major calamity. Western neighbours invade and later there are floods. When a comet travels east and points west, there are uprisings in the east.

☿ When a comet appears in the constellation of Virgo, some places are flooded and there is severe famine. People eat each other... If the comet appears in the constellation Scorpio, there are uprisings and the Emperor in his palace has many worries. The price of rice goes up. People migrate. There is a plague of locusts.

☿ When a comet appears in the comet Andromeda, there are floods and migrations of people. Many rise up and the country is divided by civil war. When a comet appears in the constellation Pisces, there is first drought and later flooding. Rice is expensive. Domesticated animals die and an epidemic strikes the army.

☿ When a comet travels into the constellation Taurus, in the middle of the double month, blood is shed... dead bodies lie on the ground. Within three years, the Emperor dies and the country is in chaos. When a comet appears in Orion, there are major uprisings, Princes and Ministers conspire to become Emperor. The Emperor has many worries, everywhere there is disaster by war...

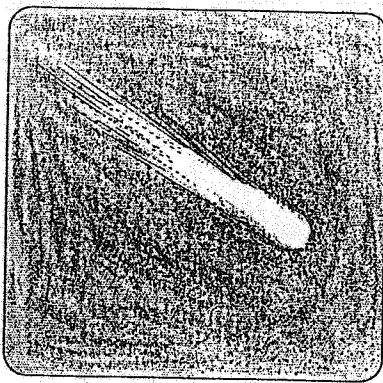
( The chinese calendar at this time was a *lunar* one, but in every year there was a *double month* to adjust to solar time.)

☿ When a comet appears in the constellation Hydra, there is war and some conspire to overthrow the Emperor. Fish and salt are expensive. The Emperor dies. Rice also becomes expensive. There is no Emperor in the country. The people hate life and don't even want to speak of it.

## Halley's poor Comet !

The Halley's comet appeared in 1066 A.D.. Many people assumed it was responsible for the killing of king Harold in the Battle of Hastings. (But the Normans won this battle !). In 1910 king Edward VII died due to natural causes. But peculiarly, it was blamed on comet Halley. In 1811, a comet blazed through the skies. But taking it as a bad sign, Napoleon's mighty army retreated from Russia. It shows how comets have always been regarded as puzzling and mysterious astronomical bodies.

Astrologers and prophets almost invariably saw comets as portents of disasters such as famines, plagues and military defeats. Comets are said to have appeared just before the deaths of such notables as Attila the Hun ( AD 453), the Prophet Mohammed ( AD 632), Richard the Lion Heart (1198) and Napoleon (1821).

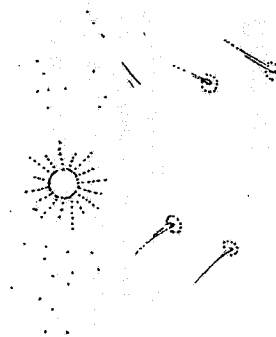


( Halley's Comet )

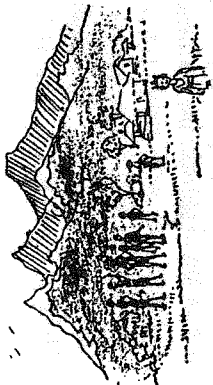
## Himalayan beliefs

Early beliefs related comets with dragons and serpents. Folklores from different communities are quite interesting and reflect their belief and traditions. Tribals in

the North eastern Himalayan belt talk of a time when there were many suns in the sky. Perhaps what the ancient people actually saw was one sun and many comets. They believe that except one sun, the rest were shot down.



Some others say comets descended in the form of a serpent. All of them, however, concur that it was only then that the earth cooled and life started.



( Comets to Himalayan tribes )

The scientific community also believes that the original seeding of the earth's ocean and therefore life itself could have come from comets. Earth became very hot during its formative process due to radioactivity and proximity to the Sun. To put together a large chemical molecule would have been complex, unless some cold material coming from somewhere had fallen on earth.

### Comet, Comete and Comets

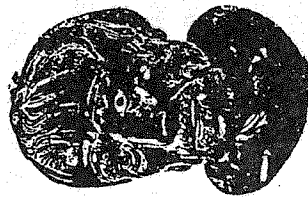
It is interesting to note that a kind of hummingbird with a long tail is known as Comete. In mythology, there is also a character called Comets. He was friend of Diomedes. Diomedes had to leave for the Trojan war. So he entrusted his wife to Comets and left home. But Comets betrayed him. This guided the ancients to believe that comets also betrayed life on earth like the mythological Comets.

## Changing beliefs

The best inquiring minds of the Chaldeans, Egyptians, Greeks and Romans made serious attempt to explain comets. The eighteenth century French astronomer and historian Alexander Pingre grouped their ideas into three classes : (1) those that claimed comets are truly heavenly bodies (2) those that argued they are close to the earth, and are atmospheric/meteorological phenomena, and (3) those that considered them to be optical illusions. Quite a few thinkers had the third belief.

Aristotle, in the fourth century B.C., believed that comets are earthly exhalations. This was challenged later on. A number of ancient philosophers maintained that comets are wandering heavenly bodies like the planets, but different in appearance and following somewhat different paths or laws of motion. Most remarkable was the insight of Seneca, advisor to the Roman Emperor Nero. Seneca, living some 400 years after Aristotle, asked whether the Earth itself might be rotating, instead of the invisible celestial spheres. Seneca considered comets to be a type of planet and predicted:

*Some day there will arise a man who will demonstrate in what region of the heavens the comets take their way; why they journey so far apart from the other planets; what their size, their nature.*



( Lucius Annaeus Seneca of Rome )

His non-geocentric argument would not stem the forceful tide of Aristotle's opinions, however. But gradually people started questioning the older ideas about comets.



## Comets in Indian Records

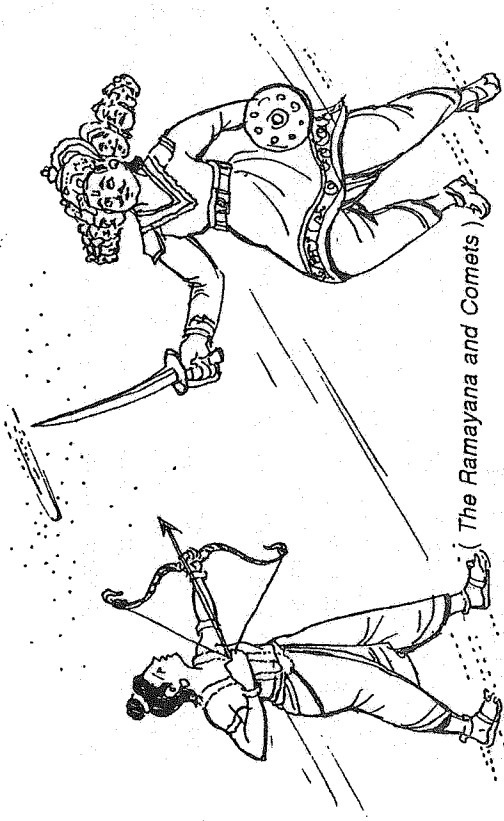
It is astonishing that no book on astronomy by the westerners mentions any name of Indian astronomers on comets. Even modern Indian astrophysicists and astronomers have not mentioned any Indian work. Sometimes Varahamihira's name has been mentioned, but no one has pointed out what he or his predecessors have done regarding comets and astronomy. But we know that once upon a time India was leading the world in the subject of astronomy. Indian history tells us that Arabs got the knowledge of Astronomy from the Indians and the Greeks got this knowledge from Arabs.

Since the Vedic period, thousands of texts are available. These texts are on various subjects, some of which are : 1. Epics, 2. Puranas, 3. Tantra, 4. Jainism, 5. Lexicons, 6. Arthasashtra, 7. Astronomy, 8. Astrology, 9. Kavya, 10. Medicine, 11. Historical poems, 12. Gnostic poetry, 13. Anthology, 14. Brihatkatha, 15. Drama, 16. Farces, 17. Minor Drama, 18. Dharma and other Sanskrit inscriptions. We find reference of comets in all these books. Let us look at them systematically.

- **VEDAS : Rig Veda** 7.33 gives how comets are formed from the Sun. In this, comets have been described as Vasishta Putra. They were supposed to be moving with fire in the sky.

*Yajurveda* also described comets in the same way as in *Rig Veda*.

*Atharva Veda* has described Aruna, as a reddish comet. This comet looks like the shape of a chouri. Besides comets, it has also touched upon meteors.



- The *Ramayana* also refers to comets. The well known of all the references is that of a comet which was observed at the start of the Rama-Ravana war. This comet was observed in the Mula constellation.

Another reference says that Rohini is covered by a comet, just like the planet. One more incident says that the waning of the bright moon was caused by a fiery comet, who was near Roudri (Adra) star. It leads to the destruction of the people.

- The *Mahabharata* also refers to the comets on certain points. The best known of all is a comet that was observed at the start of Mahabharata war. This comet was observed in the Pushya constellation.

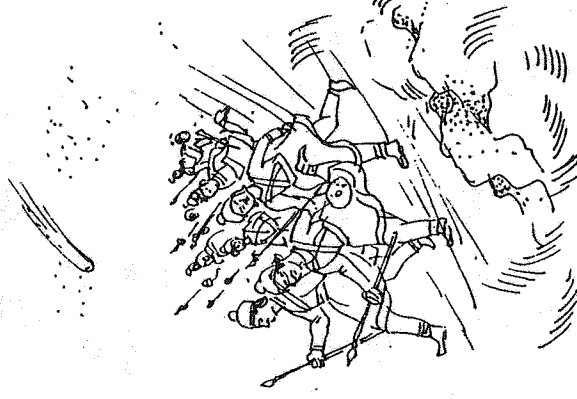
In Mahabharata there is another description which reminds us about comets. There is a reference to Skanda. Lord Indra pierced Skanda with an arrow. Skanda turned into two distinct bodies each one developing into a warrior.

This is assumed to be the description of a comet. Sometimes comets also split. This situation can be possible

if a comet crashes on the Earth. In Bhismaparva (6.3.12) it is written that the ferocious comet is stabled crossing the Pushya constellation. The Adiparva says : The comet is fire. Like the Sun spreads light, the comets spread fire.

- The *Puranas* are very old literatures in Sanskrit Out of the 18 *Puranas*, 11 have referred to comets. *The Saura Purana* says " comets rise just as a wild burning fire", *Bhavisya Purana* says, " Constellations seems smoky due to comets". *Ganesh Purana*, *Nilamat Purana*, *Brahma vaivarta Purana* and *Vishnu Purana* have similar references.

*Matsya Purana* says,  
"comet is one forth less  
than the Jupiter in size.  
Comets who are crooked  
(in shape) have an  
appearance of half the moon  
whose comas are fire..."



*Agni Purana* says,  
"Earthquake and enemy  
follow the direction from  
which comet rises or sets".  
*Vayu Purana* narrates, "It is  
said that of all planets, planet  
Saturn is the biggest, Venus  
is brighter and of all the  
comets, comet DHUMAVAN  
is the brightest".

( Views of the *Agni Purana* )

*Brahmanda Purana* (1.24.139) points out the same as above. *Bhagwat Purana* says, "The fear for us created by planets, comet or person and other reasons, may be destroyed by the name of God", "Salute to him the comet unto the demon engaged in misdeeds".

The *Brihad Samhita*, a treatise on astrology, enumerates 108 types of comets and their effects. Besides these there are hundreds of other sanskrit books which refer to comets somewhere or other. *Kaushika Sutra*, *Saravali*, *Manvarthamuktavali*, *Simhasanadwatrimisika*, *Namamalika of Bhoja*, *Saktisamagama*, *Abdhutasagara*, *Narada Samhita*, *Rajatarangiri*, *Harsha Charita*, *Trikandesa*, *Kadambarisar*, etc. have touched upon comets. Some experts are as follows :

- Comet named KACHA was observed in the Aslesha constellation which was visible at day time.  
... *Saravali*
- Luminous bodies with tails and tufts indications of calamities  
... *Manvarthamuktavali*
- The king and his subjects felt the earthquake, heat in all the directions and other calamities caused by a comet, in the city of Ujjain.  
... *Simhasanadwatrimisika*
- (Some) stars are visible in the day time. Similarly, (some) comets are also visible in day time.  
... *Namamalika of Bhoja*
- The comet together with the meteor has Bharni and other thirteen constellations which do not follow the moon.  
... *Harivansha*
- There is no rule that a comet should rise in a particular direction, however only rise of comet SAMVARTTA is denoted.  
... *Abdhutasagara*
- The characteristics of a comet are said to be thus - it resembles a smoky banner, it has a smoky tail, looks like a smoky fire and has got the appearance of a smoky star.  
... *Abdhutasagara*
- Meteors are the sons of comet. Hairless parts of the meteor glow. There are 101 comets says sage Atharva  
... *Abdhutasagara*
- The comet seen in the Kritika constellation destroys population  
... *Narada Samhita*

- A comet, the producer of evil effects is visible in the sky near Jyestha constellation. It looks like Lord Indra's smoky and linear banner. ... *Abdhutasagara*

- The comet who encircled the sky and who is the cause of destruction of the population, such a comet was observed at night in the north.... *Rajatarangini*

- Comets resembling spreaded feathers of a peacock and who are having rough and crooked tails and who are the producer of evil effects such inauspicious comets with their tails upwards were seen over the earth.

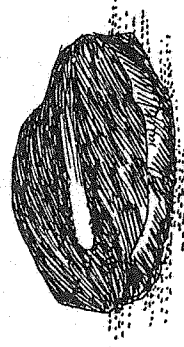
... Harsha Charitra

Besides these Trikandasesa, Kadambarisar, Sukraniti, Sarangadhara Paddhatti, Balambhatti, Bhela Samhita, Geeta govinda, Harivamsa, Siddhanta Kaumudi, Nirukta of Yaska, Venisamhara, Kumarasambhava, Dhruvasamagama etc. do mention about comets.

### Stone tablets

Excavations done by the Archaeological Department at Mehungaon found a stone tablet of 653 A.D. where on it, "An armoured king who has got a sword in his right hand is compared to a comet which looks like a sword held in right hand."

A stone tablet known as Hirekesar stone tablet belongs to 1060 A.D. . On this tablet it is inscribed that a king has been bestowed with a degree as Malava Dhumaketu.

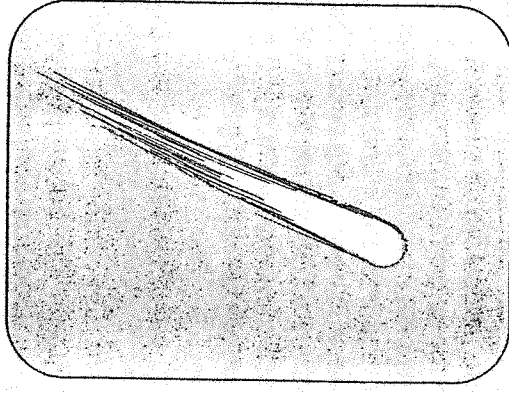


( Stone tablets )

Saint Dhyaneshwara of 13th century in his book Dhyaneshwari quotes one stanza as follows : *The rise of comet bring with it calamities to the world.*

One more example is seen in Ekanathi Bhagwat, written by the Saint Ekanath. Probably this is the only reference where at one time three comets were seen and out of that one was visible in the day time. Saint Ekanath belongs to the 16th century. According to this book three comets namely *Dhumaketu*, *Dandaketu* and *Shikhaketu* rose in the sky.

*Shikhaketu* had a spectacular tail. It was visible even in the day time. Saint Ekanath belonged to the period of 1528 to 1599 A.D.. It is likely that he must have seen the daylight comet of 1577 which was observable during day time. This 1577 comet was one of the five brightest comets known till now and Saint Ekanath named it as *Shikhaketu*.



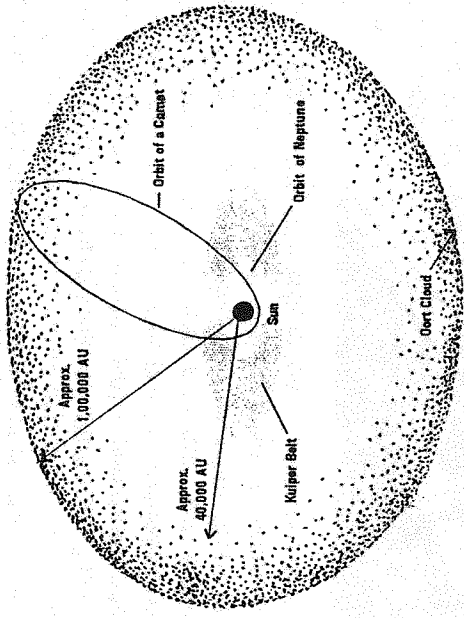
( *Shikhaketu* in day sky )

Saint Sri Samartha Ramdas, who belongs to the same period of King Shivaji, i.e., 17th century, also gives a reference of a comet as below :

*Suddenly sometime back there was Earthquake and comet rose in the sky.*

Historical evidence show that at the time of the death of king Shivaji, there was an earthquake and a comet appeared in the sky.

Thus we have record of comets in Sanskrit from vedic period till the 16th century. Other Indian languages might be having more such references.



( Schematic drawing of the Oort Cloud )

proposed by Dutch Astronomer Jan Oort after the world war-II. This is supposed to be the swarm of trillions of icy bodies. In this cold region, temperature is very low. This has two main sections: an inner part, that is approximately a flattened disk called the *Kuiper Belt* and an outer, a spherical cloud surrounding the solar system completely.

Comets were formed very long back here from ice of gases such as methane, water vapour and ammonia together with dust from primitive rock compounds. These are icy lamps, wandering icebergs sometimes described as "*dirty snowballs*". Each comet nucleus travels along its own path in the Oort cloud and takes millions of years to complete an orbit. Their temperature is a mere-240° celsius. Hence their gas and ice remains deep frozen.

## Dirty Snowballs !!

So far as the structure of a comet is concerned, it has two major parts : *Tail* and *coma*. The tail of the comet is a long and narrow stream of dust and gas. Sometimes it

## Comets To-day

In recent times, we have been hearing frequently about comets. In 1995, comet Shoemaker Levy-9 crashed against Jupiter. Interested astronomers, both amateurs and professionals, had their eyes and lenses focussed on Jupiter to study its impact. In March 1996, comet Hyakutake appeared in the sky. Many people could not enjoy the beauty of its long tail due to heavy clouds and light pollution in towns. But people in dark villages could witness the long tail of the comet for quite some days.

In 1997, the attraction of the Total solar Eclipse in Mongolia would be multiplied as the comet Hale Bopp would exhibit its bright shape during the Totality. This would give the Eclipse chasers a unique chance to observe the grandeur of the comet quite near the sun. The comet hunters are curious to study it. Common people would also be interested to know about comets in general, what are they, where do they come from, their structure, periodicity and life. We would try to touch upon these common queries.

## Home of the Comets

Like all of us comets also have home of their own. Let us look at our solar system. We start from Sun and move outwards passing the planetary orbits one by one. As we cross Pluto's orbit we would feel the attraction and influence of Sun to be less gradually. Here we would come across a great sphere which is nearly 200,000 a.u. wide (one a.u. is equal to 15 crore kilometers, i.e., the distance between the Earth and the Sun)

This area is known as the **Oort cloud**, which is actually the sweet home of the comets. This region was

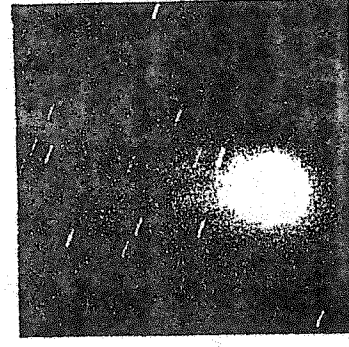


## The Composition of Comets

When a comet travels near the Sun, scientists get a chance to study its different parts minutely and systematically. The escaped gas from them offers us ways to probe its composition. Spectral analysis of the gases in the coma and tail show that they are rich in water, carbon dioxide ( $\text{CO}_2$ ), carbon monoxide ( $\text{CO}$ ) and small amounts of other gases which have condensed long back. The ultraviolet radiation from the sun breaks up the evaporating water into Oxygen and Hydrogen. Hence we find vast clouds of Hydrogen around the comets. Everytime the comet passes by the Sun, it loses some of its gas. Some comets literally fall into the Sun.

Gradually comet falls inward towards inner solar system. It is affected by the solar radiations. It gets heated and its ice content begins to melt. When it reaches near Jupiter's orbit, the heat becomes sufficient to vaporise the ice. It turns into gaseous form and forms the coma around the comet nucleus. Previously, the gases in frozen state, were carrying tiny dust grains. The nucleus was full of these.

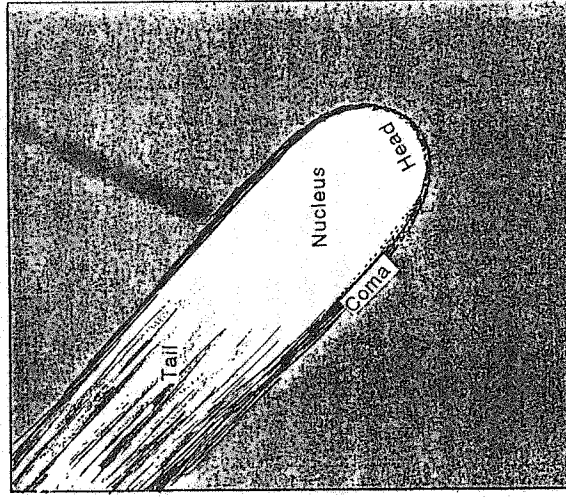
At this stage, the comet is not visible to us in naked eye. Through the telescopes, we can locate it. It looks like a dim, fuzzy ball through the lens. As it moves towards the Sun, it gets more heat. Its gases start boiling off even faster. The Sun begins to exert additional forces on the cometary gas and dust.



( A Beautiful fuzzy ball )

extends upto 10 crores kilometers, across the inner solar system. This emerges from a cloud of gas called the coma. This extends upto one lakh kms. in diameter. This is ten times or so the size of the Earth. But in comparison to their massive volume, the coma and the tail actually contain very little mass. Here the gas and dust are extremely tenuous. If you analyze a cubic c.m. of these gases you will find only a few thousand atoms and molecules. By terrestrial standards this would be considered a superb vacuum.

The coma contains a nucleus. This is a block of ice and gas only. It has an irregular mass and remains frozen in the extreme cold of the interplanetary space. Its approximate diameter is 10 kms. This is described as a giant 'iceberg' or 'dirty snowball'. This is the most massive part of the comet.

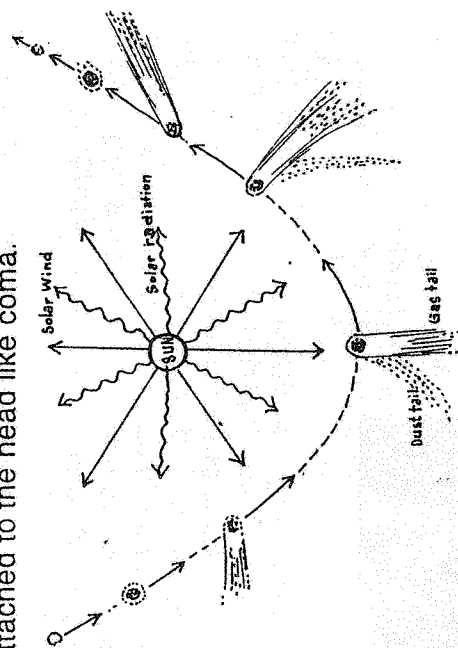


( The Beauty of the Dirty Snow balls )

Studies were conducted during the visit of Halley's comet in 1985-86. That time a space craft was sent by Europe to its nearby region. The name of the space-craft was Giotto. It was named as per the famous Italian artist Giotto. It studied the comet from close quarters. The photographs and data clarified the structure of the comet's nucleus. The photographs clearly revealed the presence, shape and composition of the nucleus.

## The tail elongates .....

We get the solar radiation everyday on earth. It supplies us light and heat. We feel only the heat and light. Simultaneously, the solar radiation exerts some pressure on us also. But we don't feel this because of our comparatively big size. This process of sunlight-striking is called *radiation pressure*. It exerts the same on the cometary dust grains with little force. This is too much for the tiny dust particles. They are pushed by the pressure away from the Sun. All of them move in a particular direction. They are not separated from the coma, but remain attached to the head like coma.

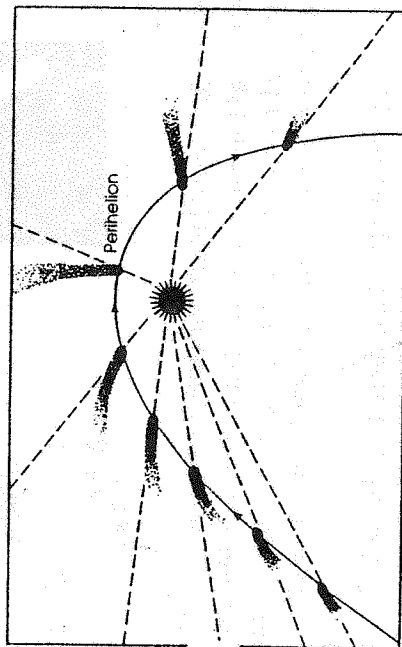


( The effect of Solar wind and radiation pressure on a Comet )

A tail keeps on elongating. Comets often have a second tail. This is formed due to a second pressure exerted by the Sun. The Sun, along with radiation pressure, has the *solar wind*. This is a continuous outflow of gas from the sun into space. This wind is quite fast. It blows away from the Sun at a speed of 400 kms. per second. It is quite tenuous. It contains only a few atoms per cubic centimeter. But the material in the comet's coma is tenuous too. The

solar wind is dense enough by comparison. It blows the comet's coma into a long plume.

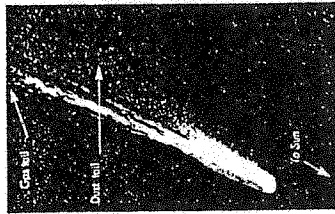
The radiation pressure and the solar wind are directed away from the Sun. Hence the comet's tail always points away from the Sun. If we keep on watching a comet regularly we can feel the change. The comet becomes visible in the night.



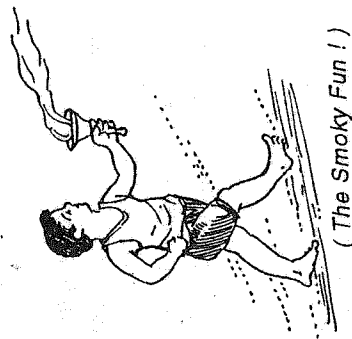
( The Tail streams away from the Sun )

Its tail always points opposite to the Sun. If we keep on plotting the position of the comet for a long time, we can see how it maintains that. Simultaneously, we can see the change in the length of the tail also. As it approaches the Sun more and more, its tail keeps on getting elongated. But as it recedes away from it, the tail's length keeps on reducing.

This could be easily understood by a simple example. Suppose, you are running with a flame in your hand. Smoke will be rising from the flame. If the air is still, the smoke will trail behind you. But if a strong wind is blowing, what will happen to the flame? It would be carried along in the direction of the wind. It does not matter which direction you run in. It would be just carried away by the strong wind.



( The Dust tail and Gas tail )



( The Smoky Fun ! )

So the smoke would start from the flame, but would find the direction of the wind only. Likewise the high velocity of the solar wind carries the tenuous tail of the comet outward from the Sun regardless of the comet's motion and direction.

### How is the tail visible to us ?

Have you ever looked at smoke rising from your chimney ? It looks white or dark and moves up. If the sky is blue the smoke is visible. If the sky is dark or cloudy, the smoke becomes very difficult or impossible to decipher. The background dark sky prevents its visibility. But what happens to the comet ? It does not have illumination like stars nor is it hard to reflect sunlight like the planets. It is only dirty snowballs after all ! So the question turns out to be quite interesting. How a gaseous stream becomes visible, when the background is totally dark ?

Let us analyse it systematically. The sunlight falls on the gas and dust particles of the comet. The sunlight has got particular wavelength, when they fall on the gases and dust of the tail, these particles get lit up. The dust particles reflect sunlight and the gases emit light of their own. This

process is called *fluorescence*. This is a phenomenon when light of one wavelength is converted into light of another wavelength. The ultra-violet light from the Sun lifts electrons in the atoms of the comet's gas molecules to an upper, excited level in a single leap. Then these electrons return to their original level. For their return, they take two or more steps. At every step they emit some energy. Thereby we see some light. The particles seem to be glowing little bit. The continuous process of fluorescence creates the soft glow of the comet's light.

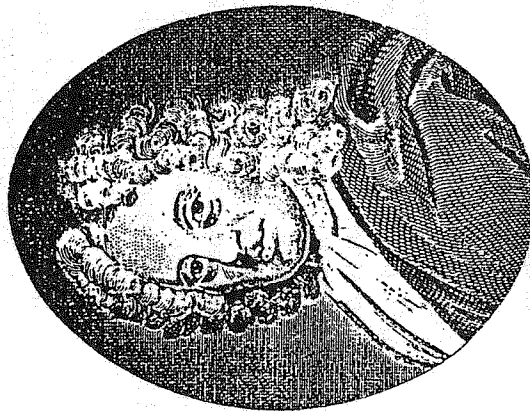
For common people this process is bit complicated to understand. But people are familiar with this process in daily lives also. Now-a-days fluorescent colours are being used for advertisement, banners, dress materials and books. These things keep on glowing softly and attract attentions effectively. The comets' glowing is somewhat similar. For us it is of great help. It enables us to enjoy the beauty of the comets. For this glowing, the comets become visible in spite of the dark background sky.

### How they are named ?

Like any other celestial body, the comet moves across the sky. For our reference we give it a name. It finds its name as per its discoverer. We know how comet SL-9 was discovered and named. It is called Shoemaker -Levy 9. It was a team work. The Shoemaker couple and David Levy discovered it for the first time. Accordingly it found its name. Comet Hyakutake was located by amateur astronomer Yuji Hyakutake in Japan. So was the case of Hale-Bopp and other comets.

There are few exceptions to this. There was a time when individual achievement was out of favour in the People's Republic of China. A comet discovered, that time, was named as Purple Mountain Observatory comet. Sometimes comets are named after those who first recognized that the comets seen in two or more apparitions were really the return of the same comet. Halley's comet and comet Encke are examples of this type.

Halley's is the best known comet in the world. Halley was a colleague of Isaac Newton. He realized that the great comets of 1531, 1607 and 1682 were all periodic returns of the same comet. He predicted that it would return again at the end of 1758 or the beginning of 1759. Halley died in 1742. He failed to verify his prediction. But his comet returned right on schedule. It appeared in December 1758 and reached perihelion in March 1759. Hence this comet thereafter was known as the Halley's comet.



( Edmund Halley )

Comets are also designated by a Roman numeral, designating the position in the sequence of perihelion passages in a given year- as 1858 VI or, 1988. Such technical names of comet Hyakutake and comet Hale Bopp are C/1996 B<sub>2</sub> and C/1995 O1 respectively. The International Astronomical Union (IAU) gives the technical names to the newly identified comets.

## Types of comets

Basically comets are classified into two major types as per their periodicity. They are *Long period types* and *Short period types*. The long period types are with orbits more than 200 years. They become visible to us when they complete the orbital cycle and head towards the Sun. Humans can never observe a single comet of this type for second time in their lives. Because we live for a mere 60-70 years only. The comets begin as long period types making the long journey from the Oort cloud. Gradually they are captured by the gravitational fields of the planets in the interplanetary space. Jupiter exerts high pull on them for its heavy mass. So, gradually the long period type comets are transferred into new orbits near the Sun.

There are such long period comets who have orbital periods of more than a million years even. In their initial stage, they can have orbits at any angle, because they can come from any region of the Oort cloud. But sometime or other they are affected by the strong gravitational pull of the massive planets and are captured. Then they nearly all fall into line with the movement of the planets. They stay close to the ecliptic. They also orbit the Sun in the same direction as the planets. Many comets have followed this path. But Halley's comet, we are most familiar with, is an exception. This is a short-period comet with an orbital period of about 76 years. This has not fallen in line with the planets' motion. It rather has a retrograde motion.

## Fate of short-period comets

The origin and fate of short period comets is still under study. Previously scientists were thinking that they come from the Oort cloud. When they were passing through the solar system, Jupiter like big planets exerted



pressure(attraction) on them. These encounters changed the course of their paths. Their million year long orbits were modified to some hundred years only. But the present astronomers consider the phenomenon in a different way. They think that short-period comets come from a second group of icy nuclei, orbiting beyond Neptune. This is within the main part of the Solar system. This region is the *Kuiper belt*. Recent detection of several small icy bodies beyond Pluto has supported this theoretical argument substantially.

The short-period comets keep on moving past the Sun frequently. Everytime they move near the Sun, all their ice and gases evaporate. Only the small amount of solid matter, dust and grit, remains. This fate is like that of a snowball made out of snow with small amount of gravel.

After getting some sunlight, this snowball melts and evaporates leaving behind the small amount of gravel. So too, the evaporated comet leaves behind in its orbit some grit. These materials continue to rotate around the Sun. They are the source of meteors.



( The fate of a Snow ball )

## Meteors, meteors all the sky !

If you look at a clear night sky you can see a splash of light across the sky around every fifteen minutes. They are meteors. Sometimes they appear in large number and frequency. They become visible nearly every minute or so. If you observe them carefully, you can mark that they appear from the same general direction in the sky. These types of meteors are called " *shower meteors*". This event is called a ' *Meteor shower*'.

Every year we can enjoy such a meteor shower in mid-August. A number of meteors keep on raining near constellation Perseus. Actually they are not associated with Perseus. Rather, that time, they happen to be travelling around the Sun roughly in that direction. The Earth happens to cross their orbits in mid-August. Hence we encounter more meteoroides at that time than usual. These events are really spectacular to watch in the sky.

## Some Famous comets

	<i>Orbital Period</i>	<i>First seen</i>
Encke's	3.3 years	1786
Pons-winnecke	6.0 years	1819
Biela's	6.6 years	1772
Holme's	6.85 years	1892
Schwassmann		
Wachmann I	16.2 years	1925
Halley's	76 years	240 B.C.
Ikeya-Seki	880 years	1965
Donati's	2040 years	1858
Humason's	2900 years	1961
Arend-Roland	10,000 years	1957
Kohoutek's	75,000 years	1973

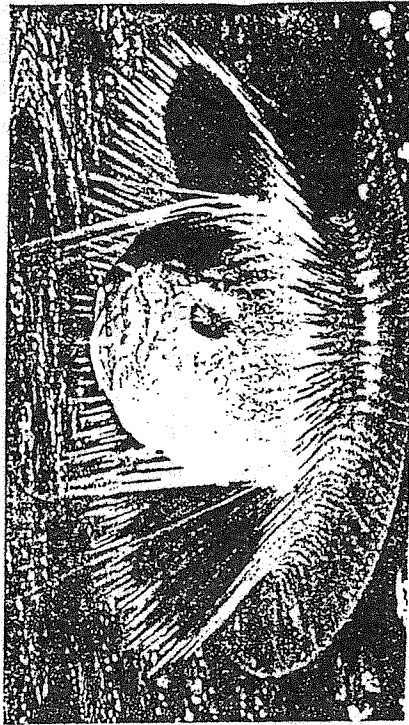
## Attack Earth !

Sometimes, may be every few thousand years, the Earth is hit by a huge meteoroid. The size of such bodies varies from tens of meters to much more even. They produce a spectacular glare as they pass through the atmosphere. On impact, they create enormous blast.

We have got proofs of these giant meteor impacts. There are quite a number of giant meteor craters on Earth. One of the most famous meteor impacts is at northern Arizona, which formed a giant crater at the spot. It occurred about 50,000 years ago. The meteor is estimated to have been some 50 meters in diameter. Its impact vaporized tons of rock, which expanded and peeled back the ground. This created a big crater of about 1.2 kilometers across and 200 meters deep.

### Some amazing incidents.....

Russia saw one of the biggest accidents on 30th June 1908. This was caused in Siberia by a moving body from space. It was winter time and the local river Tunguska was frozen. But the accident changed the situation dramatically. A bright fire ball streaked northwards at great speed. It appeared like a piece of the brilliant Sun which had broken off. Some people felt that the ground rose and fell like a wave. The vibration tremors were recorded even thousands of kilometers away. Areas of forest were devastated, trees burnt and levelled radially onward from the blast point to a distance of some 30 kilometers.



( What a massive blow to Earth ! )

The blast was preceded by a brilliant fireball in the sky and was followed by clouds of dust that rose to the upper atmosphere. Sunlight reflected of this dust gave an eerie glow to the night sky for several days.

Unfortunately, scientists did not visit the spot until about two decades later because of the political turmoil in Russia at that time. When they reached the site, they found no crater, just the felled trees. There were hundreds of small depressions, but not a trace of the fire-ball that hit the ground. Interestingly, trees at the centre of the damaged area were left standing vertically, but their branches were missing. This indicated the type of the explosion in the air blast, but no crater or meteoritic fragments might be due to a comet. On entering the atmosphere, the cometary ices would have heated and expanded explosively. If any piece survived to reach the ground, they would have melted long before anyone explored the area.

### Jahangir and the thunder !

It was 1621-the Jahangir era. One morning there was a thundering noise. In a village near Jallandhar, a light was seen falling from the sky. Mohammed Said was the collector of that pargana. He rushed to the spot on horseback. He saw a different thing.

The Earth was found scorched for many square yards. The charred area was dug to analyze the event. From this, 150 tolas of hot iron was collected. Jahangir was fascinated by this. He ordered that a knife, a dagger, and a sword be fashioned out of it ! Unlike the Tunguska fire ball, the one that fell near Jallandhar not only left a trace, but was converted into the most unique pieces of weaponry.

## An encounter with the Sun !

Planet Jupiter is said to be a comet disturber. Its massive gravity can capture a passing comet and deflect it into a much smaller orbit. It can also fling a comet completely out of the solar system.

Sometimes it so happens that a comet encounters even with the Sun. A close encounter with the sun can produce more peculiar effects. One such example is the comet Biela. It was a five year period comet of the 19th century. It broke into two. Each one grew its own coma and tail. At the time of its expected return in 1851 no comet was seen. Instead a spectacular meteor shower was observed. Biela had apparently completely disintegrated.

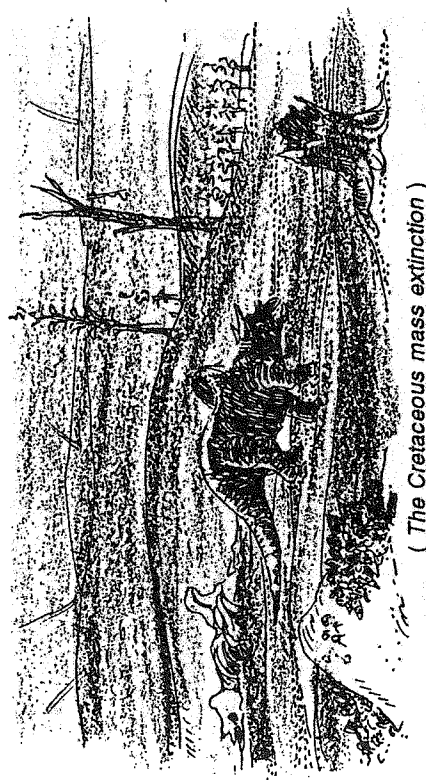
The crater created at Lonar lake in Maharashtra has attracted attention of many astronomers, both professionals and amateurs. This is also supposed to have been created due to a giant meteor impact at that spot.

## Mass Extinctions !

The Earth is hit now and then by large asteroids or cometary bodies, producing craters or, in very rare instances, *mass extinctions*. This theory has, generated much curiosity among scientists. This has been reasonably supported by different evidences.

We know that the Earth's living world has been in a changing process (evolution) since its beginning. It has been a remarkable process. There was a time 20 crores years back, when the Earth was ruled by the giant lizards

called *dinosaurs*. Hundreds of different types of dinosaurs were dominant in the land, water and sky. But surprisingly the whole scenario changed abruptly around 6.5 crores years back. The whole dinosaur generation got extinct by some incredible phenomenon. Scientists have been looking forward to an appropriate answer to this massive extinction. This extinction is called the *Cretaceous mass extinction*, because it occurred at the end of the Cretaceous period about 6.5 crores years back.



( The Cretaceous mass extinction )

The most appropriate evidence to this incidence comes from the relatively high abundance of Iridium inside the Earth's deep interior. Iridium is quite a heavy element. This is rarely found on the earth's surface. But the layer of Iridium in Earth's interior suggests that they must have been deposited 6.5 crores years back. On the other hand, samples of meteoritic materials have shown moderate amounts of Iridium.

This has developed a link of this incidence of meteoritic material. The amount of in Iridium in the Earth sediments at that layer is the quantity that would be dispersed from a piece of meteoritic material 10 kilometers in diameter. This might be an asteroid or comet. Its impact and the

subsequent disruption to the atmosphere is blamed for exterminating the dinosaurs and many less conspicuous but widespread creatures and plants.

A 10 kilometers-sized asteroid hitting the Earth would produce a severe explosion on impact. It would be equivalent to that of several billion nuclear weapons. The impact would make an immense crater. It would also blast huge amounts of dust and molten rock into the air. The molten rock raining down would raise the surface temperature as high as that under an electric broiler and ignite global wildfires.

The hot fragments and blast would also create nitrogen oxides, which would combine with water to form a rain of highly concentrated nitric acid. This devastating combination of heat, acid rain and blast would be followed by months of darkness and intense cold caused by the dust shroud. This would blot out the sun rays. This would have an devastating effect on the biosphere.

Along with the underground Iridium layer, we see layer of soot and layer of tiny quartz pellets believed to have been created by the melting and blast of a violent impact. This Cretaceous mass extinction might have played an important role in our own evolution.

During the Dinosaurs' period, reptiles were the largest animals. Mammals like rats were quite small. But the devastation made lives of the giant animals unbearable. But the small animals could escape the fury of the heat and acid rain by remaining in burrows. They could also survive the subsequent cold by virtue of their fur. Subsequently the mammals took up the position of dinosaurs without any threat and dominated today's Earth.

Other mass extinctions have occurred earlier and later than the Cretaceous event. Few scientists believe that our planet is bombarded roughly every 26 million years.

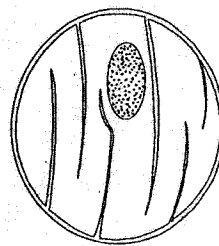
### Some Mass Extinctions

<i>Geological period when extinction occurred</i>	<i>Crates of years ago</i>
Ordovician .....	43.5
Devonian .....	36.5
Permian .....	24.5
Triassic .....	22.0
Cretaceous .....	6.5
Eocene .....	3.5

## The Comet Disturber !

In the Solar system, each body has its own strength of gravitational attraction. But comparatively Jupiter is supposed to be the king of all these solar bodies. This giant planet is nearly 320 times more massive than our own planet Earth. Comets moving close to Jupiter are thrown into new orbits by its powerful gravitational pull. Their orbits change dramatically. This is known as the capturing of comets by Jupiter.

Nearly forty five such captured comets have been identified by the astronomers. Previously these comets were going around the Sun in very long elliptical orbits, but Jupiter deflected them into relatively small orbits.



( Jupiter - The Disturber )



## Sensational SL-9

Some days back in 1994 July, Shoemaker-Levy 9 was a big attraction for comet hunters worldwide. It was a member of Jupiter family of comets. This comet ultimately succumbed to the strong pull of Jupiter, while rushing towards Jupiter. It was identified by the Earth's people. All human and telescope eyes were focussed on this. But by that time it had broken into 21 plus fragments. They all were flying at highspeed towards Jupiter like a train in the sky.



(The Train SL-9 to Planet Jupiter)

In July 1992, astronomers found that Shoemaker-Levy 9 passed 43,000 kms. from Jupiter. This was quite close for the strong gravity of Jupiter to pull the nucleus of the comet into fragments. Ultimately, these fragments were observed to hurtle one after the other over a six-day period beginning about July 16, 1994.

So far as Jupiter is concerned, it is a massive gaseous ball made of hydrogen, methane etc. Hence it could sustain this big accident without much harm to it. Large fireballs splashed high into the planet's atmosphere. The accident force waves spread on the gaseous surface of the planet like waves propagating on a pond when you throw a stone into it. There was no drastic impact on Jupiter.

But a such an accident with our Earth would have been quite destructive for its hard crust and smaller size.

The years of comets.....

## Comet Hyakutake's grand show

It was a comet-lovers dream come true! This comet had something for everybody. It was big, (its tail stretched more than 100° across the sky on March 25, 1996), rich (close-up photographs revealed its wealth), close and it was speedy (astrophotographers had to hone their tracking skills to keep up with Hyakutake's fast motion). Thus it turned out to be the "comet of this decade," and the brightest in last 20 years.



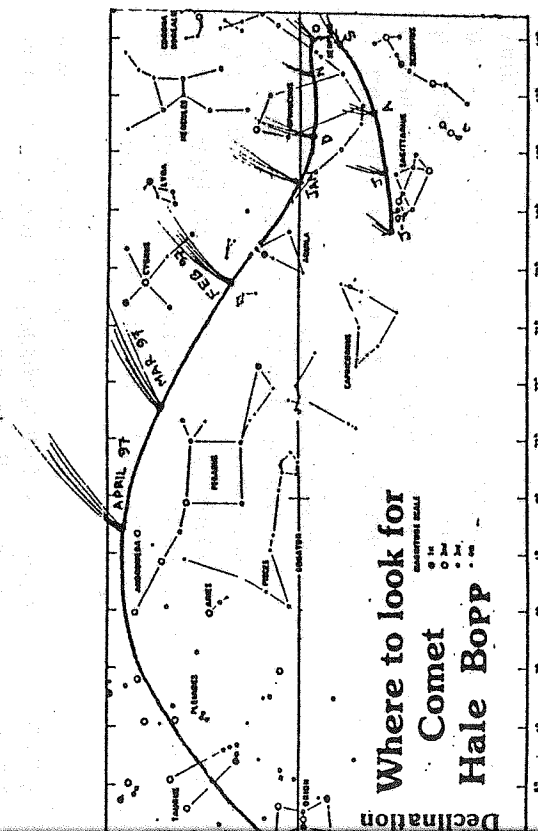
( Comet of the Decade-Hyakutake )

It was named as per its Japanese discoverer (an amateur astronomer) Hyakutake, which means a hundred bamboos. It gave us a unique opportunity to enjoy its beauty. If it had come in from the other side of the Solar system, or if the Earth had been in a different part of its orbit, it would have looked like an ordinary one. But it was different. It practically aimed its run for the inner solar system at Earth. We got the front row seats to watch this grand celestial show.

## Tour schedule of Comet Hale Bopp

For our reference, this tour of the comet Hale Bopp can be divided into four parts. They are :

- |                 |   |          |      |
|-----------------|---|----------|------|
| a. October      | - | November | 1996 |
| b. December '96 | - | January  | 1997 |
| c. February     | - | March    | 1997 |
| d. Late March   | - | April    | 1997 |

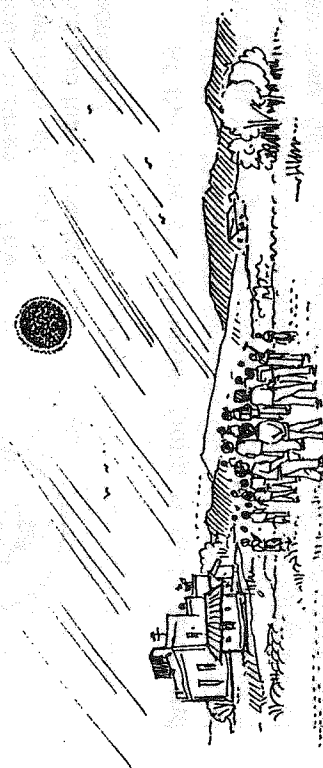


Right Ascension

- a. October - November 1996 : It is possible to watch the faint picture of the comet in very darkskies. Rural areas with least light pollution are best to watch from. The comet is visible from the evening till one o' clock in the night. The area is constellation Ophiuchus Visual magnitude is around 4.

The most challenging aspect of the comet hunting would be sensitizing common people. During the solar eclipses we see how people hide inside houses out of peculiar fear and beliefs. Most people avoid the event straightway and remain indoors. The appearance of comet also creates similar or more fear and awe in the society. It is understandable that looking straight at the eclipsing Sun might be dangerous, but watching comets is only fun and fun. There is no danger at all. But people get carried away by the old wrong interpretations and don't like coming out and watching the show.

This causes the science activists and amateur astronomers to create a right and inspiring impression in common people's mind. In 1985-86 People's Science units like K.S.S.P., etc. designed massive programmes to welcome Halley's comet. They popularised the beauty of the event quite massively. People in large number could enjoy the event. Attempts by many such groups in India at later stage have been quite successful.



In comparison to the 1980 Total solar eclipse, the 1995 Total Solar Eclipse could evoke larger number of people and response. Comet Hyakutake has already warmed up and has enhanced people's appetite for the coming comet Hale-Bopp.

**b. December '96 - January 1997 :** From Earth we can see the sun and the comet quite close to each other. The comet is easily visible right after sunset. It moves from constellation Ophiuchus towards Serpens Cauda and Aquila gradually.

**c. February - March 1997 :** By this time the comet is visible in the early morning sky. It is visible against the stars of Aquila, Vulpecula and Cygnus. Its visible magnitude is around 1 in early February and enhances to around 2 towards end of March.

The tail stretches about  $15^\circ$  to  $20^\circ$  across the sky pointing away from the sky. This gives a nice chance to the people in Mongolia and eastern Siberia on March 9, 1997. During the Total Solar Eclipse there, the Comet Hale Bopp is visible along with Mercury, Jupiter, Venus and Saturn. The comet is seen at  $46^\circ$  from the eclipsed Sun.

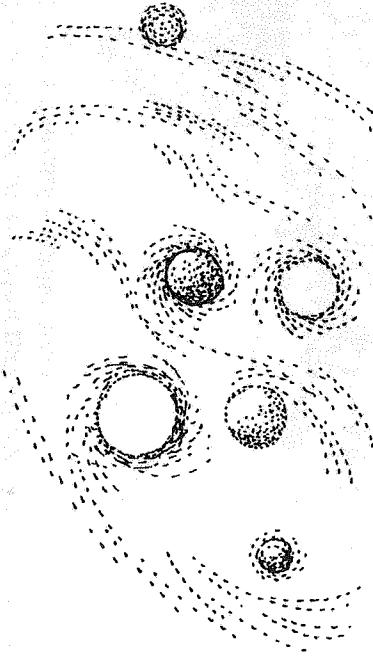
**d. Late March - April 1997 :** By late March, Hale Bopp moves to the constellation Andromeda. This is at its best. It is visible now about  $15^\circ$  to  $21^\circ$  above the north western horizon in the evening sky. This show remains visible till 14th April.

Gradually, the comet moves to Perseus from Andromeda constellation and is nearer to the Sun. By the end of April, it is difficult to spot the comet. It remains close to the flood of sunlight in the early evening sky.

On March 23, 1997, Hale-Bopp makes its closest pass to the Earth at a distance of about 20 crore kms. By June 1997, the comet might fade rapidly as it recedes from both the Sun and Earth.

## Significance of the Comets

It is believed that comets were formed 460 crores years ago at the time of the beginning of the solar system. It took a long time for Earth and other bigger bodies to cool down from their burning stage. They needed the action of wind and water continuously. But comets were the smaller fragments and they became the first solids in the solar system. They have not changed much since then. Hence they are the proof of those beginning days of the solar system. They speak of the condition of those days.



Secondly, it is expected that life originated on Earth after a long period of changes. Comets are expected to have played a role in forming the early atmosphere of the Earth. It could have been responsible for introducing complex molecules necessary for the beginning of life on Earth.

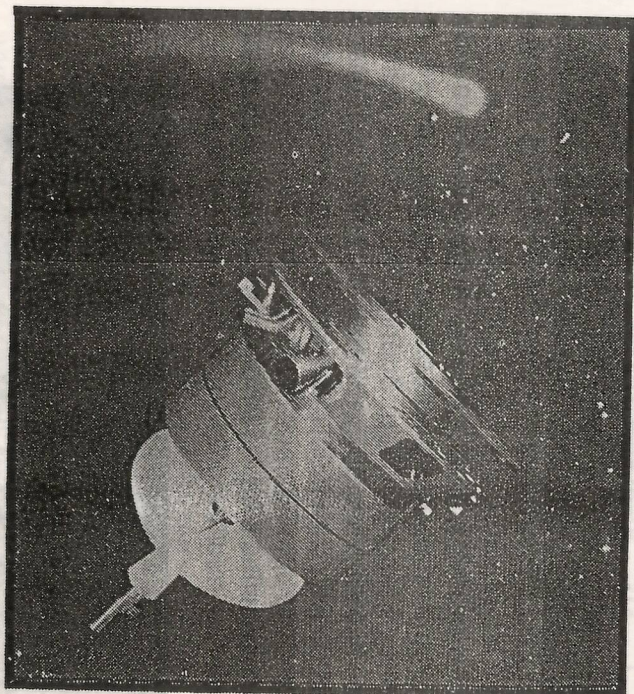
A study of the composition and structure of the comets reveals these stories. So scientists use these opportunities to discover these. Telescopes and cameras focus on the comets as long as they are in the sky. Photographs are taken from close quarters to study the comet in detail. The Giotto space craft was launched close



This was a nationwide awareness campaign by AIPSN, BGVS units to welcome the spell-binding event of the year - the Total Solar Eclipse in October '95. The major components of this massive people's campaign were : Kala Jathas, Brahmamda Melas and Surya Melas. Materials developed : Fifteen books were published in English/Hindi on Eclipse and the sky. About 50 more titles were brought out in regional languages. 100 slides were developed on 4-5 themes relating to the event. Posters, stickers and name slips were brought out to mark the occasion. Nearly about 10 lakh solar goggles were circulated.

The preparatory phase included an All India campaign titled "Joy of Learning", National Workshop at Madras, Regional workshops at Nasik, Assam, Madras and Delhi. Participation in the V All India Amateur Astronomers' Meet at Bhubaneswar and IUCAA's preparatory workshop also supplemented to this preparation.

Before the event, 2 Kala Jathas were organised along the line of totality to take the message of PSM to the people. Meghnad Saha team passed through W. Bengal, Bihar and U.P. undertaking programmes at 125 places. The Aryabhata team passed through Rajasthan and U.P. undertaking 30 programmes. Other states had separate Jathas at their level. Each state unit had independent activities through workshops, seminars, slide/poster/photo shows, sky watching programmes, solar experiments and mass viewing. In comparison to the TSE '80, this TSE generated much more interest and enthusiasm.



The European Space Agency's Giotto spacecraft (above) comes within 500 km of Comet Halley's nucleus on March 14, 1986.

Dear friends,

Every comet has got its own beauty and significance. So also is Comet Hale Bopp. All comet-hunters are aiming their lenses at it now to study its structure, composition & novelty.

Let us all focus our attention at this grand celestial show and discover something new. We wish you clear dark sky and a spectacular COSMIC VOYAGE.



## **COSMIC VOYAGE '96-'97**

▲ This is the time of comets. Comet Shoemaker Levy-9 in 1994 and Hyakutake in 1995 have generated much enthusiasm among professional and amateur astronomers. All are gearing up for the coming celestial demonstration of comet Hale Bopp. But if we look at our society, the response is not that much healthy and satisfactory. Through Cosmic Voyage-'95 we tried sincerely and devotedly to attract people in large number to watch the most beautiful event of the sky. They came with us in good number. It was definitely rewarding. But if we look at the country, as a whole, they were not even 5% of India. More than 90% people remained indoor out of fear and wrong beliefs (in this age of science!)

Comets are objects of even greater superstition. In most of the countries in the world, they are portenders of calamities and catastrophe. There is no scientific rationale or historic experience to support this belief. Science and scientific temper of people are at stake. This time is a golden one for all of us. This is an opportunity when the comet is in our sky in front of us. It may not be extraordinarily spectacular, but would be sufficiently attractive. There will be negative attempts by the unscientific community to keep people away. We would have to lodge a really massive and scientific campaign for the truth. We would use comet astronomy as an effective tool for developing a 'scientific temper' among the people. People can see the reality, debate on it and understand. This is a golden chance...

How do we go about this ?

For more about this contact :-

Cosmic Voyage Committee  
**BHARAT GYAN VIGYAN SAMITI**

West Block-2, Wing-6  
R.K. Puram, Sector-1  
New Delhi-110066

Phone : 6107911, 6107318